Original Article

Relationship between Anthropometric Parameters, Neck Circumference, and Intraocular Pressure among Normal Adults in Ile-Ife

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Abstract

Aim: To determine the relationship between anthropometric parameters, neck circumference (NC), and intraocular pressure (IOP) among the adult population in Ile-Ife, Nigeria **Method:** A descriptive cross-sectional study was conducted among 450 randomly selected nonglaucoma subjects from the students and staff population of Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Nigeria. Ethical clearance for the study was obtained from the institution and written informed consent was obtained from subjects. The demographic profile of subjects was documented and measurements of anthropometric parameters, NC, and IOP were carried out. Data were analyzed using statistical software SPSS 23.0. The bivariate linear regression model was used for correlation analysis and the level of statistical significance was set at $P < 0.05$. **Results:** Four hundred and fifty subjects were examined comprising 194 males (43.1%) and 256 females (56.9%). The mean age was 34.26 ± 11.78 years. The mean values for height, weight, body mass index (BMI), and NC were 1.67 ± 0.09 m, 70.7 ± 14 kg, 25.49 ± 4.91 kg/m2, and 34.65 ± 2.79 cm, respectively. The weight and height were significantly higher in males than in females but BMI was higher in females. The mean IOP for all the subjects was 14.40 ± 3.26 mmHg. Weight, BMI, and IOP significantly increased with age, and mean IOP also significantly increased with increasing height ($P = 0.045$), weight ($P = 0.005$), NC ($P = 0.0005$), and BMI ($P = 0.0001$). **Conclusion:** Increased weight, BMI, and NC were found to be significantly associated with IOP elevation, which is a risk factor for glaucoma

Keywords: Anthropometric parameters, intraocular pressure, neck circumference, Nigerian adults

Introduction

The relationship between anthropometric parameters and intraocular pressure (IOP) may be complex due to the association of these parameters with various systemic factors such as diabetes mellitus, hypertension, cardiovascular diseases, and obesity which are also risk factors for glaucoma. Several authors have shown varying patterns of relationship between different anthropometric parameters and IOP.[1-4] Pasquale *et al.*[1] in a prospective cohort study on the relationship between anthropometric parameters and incidence of primary open-angle glaucoma (POAG) revealed that increased body mass index (BMI) is protective of POAG especially in the female gender. Dielemans *et al.*[2] in the Rotherdam study showed no relationship between obesity and onset or severity of glaucoma in males but in females, though obesity was shown to be rather protective as obese female subjects had reduced IOP. However, other authors showed a positive relationship between IOP and BMI relative to gender and age.[3,4] Wu and Leske[3] in the Barbados eye study showed that IOP increases with increasing BMI. Lin *et al.*[4] in a Taiwan-based study reported that IOP increases with increased BMI and of more significant in the older age group.

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In Nigeria and other African countries, there are few reported studies on the relationship between IOP and anthropometric parameters among which are studies by Ebeigbe and Omokhua[5] in Benin which showed a positive relationship between IOP and BMI. Lai *et al.*[6] in Tanzanian revealed that IOP may reduce with increasing height, but found to increase with obesity. Neck circumference (NC) which is often not measured routinely along with the conventional anthropometric parameters (height, weight, and BMI) in the adult is also known to be an index for obesity.[7] Few studies were found to relate NC with IOP. Theelen *et al.*[8] found no relationship between NC and IOP but neck retroflection was found to increase IOP. Markowitz and Mitchell[9] reported that men with NC >43 cm and women with NC >40 cm were classified as high risk for sleep apnea syndrome and at high risk for developing glaucoma. The mean change in IOP from sitting to supine was higher in the group with larger NCs, although it was not statistically significant. The Markowitz and Mitchell[9] findings suggested that NC may indirectly be related to IOP.

The pattern of relationship between anthropometric parameters and IOP varies in a different environment as shown in various reports with fewer studies from the developing countries.[10-12]

This study is aimed at determining the relationship between anthropometric parameters and IOP among normal Nigerian adults.

Materials and Methods

It was a descriptive cross-sectional study carried out at Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Nigeria. The hospital is affiliated with the Obafemi Awolowo University for training medical students, nursing students, medical records, and physiotherapy students. It is also a center for postgraduate medical training in many surgical and medical subspecialties. Based on the calculated sample size, 450 subjects were randomly selected from a study population comprising staff and students of the institution between the ages of 18 and 60 years. Subjects already diagnosed to have glaucoma, ocular hypertension, or normal-tension glaucoma whether on medications or not were excluded. Subjects with current ocular infections, conditions preventing reliable applanation tonometry, or any deformity that may preclude accurate measurement of height were also excluded. Approval of the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, was obtained in accordance with the ethical standards and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Written informed consent was obtained from all individual participants included in the study. All subjects had demographic and clinical data including age, sex, and occupation. Anthropometric parameters were measured which included their height, weight, BMI, and NC. Similarly, all subjects had Snellen visual acuity and Goldmann applanation tonometry (Haag-Streit, Mason, Ohio, USA); for IOP, measurement was carried out twice at a 1-hour interval between 8 am and 12 pm and the average IOP value was computed and documented. The IOP in the right eye only was considered for analysis. Before measurement of study parameters, a detailed ocular and systemic examination were performed to rule out glaucoma and other ocular and systemic comorbidities that could cause elevated IOP and such patients were excluded from the study.

Data collected were analyzed using Statistical Package for Social Study (SPSS 22.0, Chicago, Illinois, USA) software. The mean values and standard deviations of quantitative variables were carried out. One-way analysis of variance was used to determine the effect of age groups and gender on the anthropometric parameters and IOP. Correlation analysis was performed to show the relationship between height, weight, BMI, and NC, respectively, on IOP using a bivariate linear regression model. The level of statistical significance was set at a P-value <0.05.

Results

A total of 450 subjects were recruited comprising 256 females and 194 males with a male to female ratio of 1:1.3. The subjects' age varied from 18 to 60 years with a mean age of 34.26 ± 11.78 years. Sixty-one subjects (13.6%) reported a family history of glaucoma with mean IOP $= 15.75 \pm 4.34$, 186 subjects (41.3%) reported no family history (mean IOP $=14.18 \pm 3.13$), whereas the remaining 203 subjects (45.1%) were unsure of the presence of glaucoma in their family (mean IOP $= 14.42 \pm 2.14$). P-value was 0.009. The cup to disc ratio (CDR) ranged from 0.2 to 0.8 with a mean CDR of 0.37 ± 0.13. Figure 1 and Table 1 show the effect of different age groups and genders on anthropometric parameters and IOP. The relationship between anthropometric parameters and IOP is shown in Figures 2–5 and Table 2.

Discussion

The mean age of the subjects was relatively lower when compared with the mean age (46.2 ± 9.3 years) in a study by Mori *et al.*[13] The lower mean age in this study may be adduced to the students' population with lower age group. Subjects with a family history of glaucoma were found to have relatively higher IOPs compared with those without ($P = 0.009$). This finding is similar to reports by Wu and Leske[3] in the Barbados eye study and Kapetanakis *et al.*[14] which reported higher IOP in nonglaucoma patients with a family history of glaucoma. Family history of glaucoma is supportive of the genetic theory of POAG, but the mechanism of causing elevated IOP is widely unknown. The mean height, weight, and BMI observed in this study in both sexes were slightly higher (higher mean difference) than the findings by Okosun *et al.*[15] in Nigeria. Similarly, the study mean anthropometric parameters are also higher than those obtained in Lai *et al.*[6] in Central Tanzanian, and Mori *et al.*[13] studies in Japan. However, a lower mean

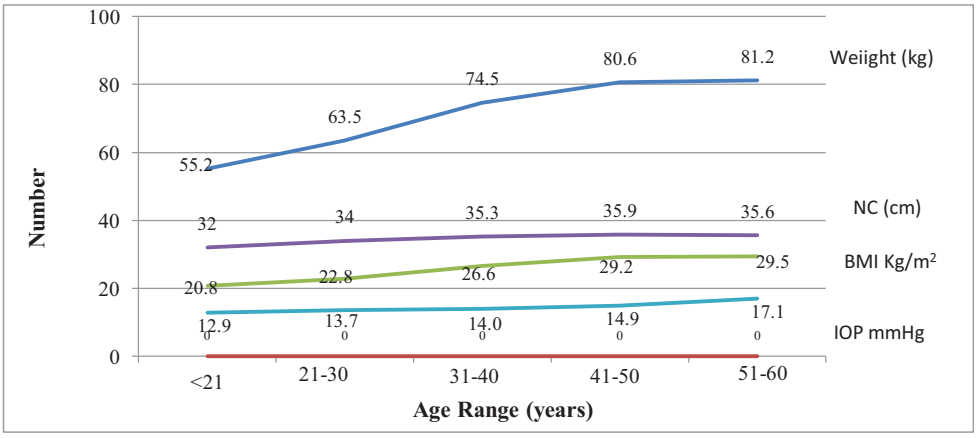

Figure 1: Effect of different age groups on weight, BMI, NC, and IOP in 450 subjects. All had a P-value <0.05, respectively. BMI, body mass index; NC, neck circumference; IOP, intraocular pressure.

Table 1: Anthropometric parameters and intraocular pressure by gender

Variables	Mean ± SD		*T*-value	*P*-value	Mean diff	Conf.interval(Low – UPP)
	Male(*N* = 194)	Female(*N* = 256)				
Height (m)	1.73 ± 0.633	1.62 ± 0.686	17.25	<0.001	0.11	0.10–0.12
Weight (kg)	73.07 ± 13.18	68.91 ± 15.07	3.06	0.002	4.16	1.49–6.84
BMI (kg/m^2)	24.47 ± 4.12	26.26 ± 5.30	–3.90	<0.001	–1.79	–2.70 to –0.89
Neck circumference (cm)	36.57 ± 2.12	33.20 ± 2.31	15.81	<0.001	3.37	2.95–3.78
IOP (mmHg)	14.70 ± 3.37	14.16 ± 3.34	1.68	0.093	0.54	–0.91 to 1.16

BMI, body mass index; IOP, intraocular pressure; SD, standard deviation.

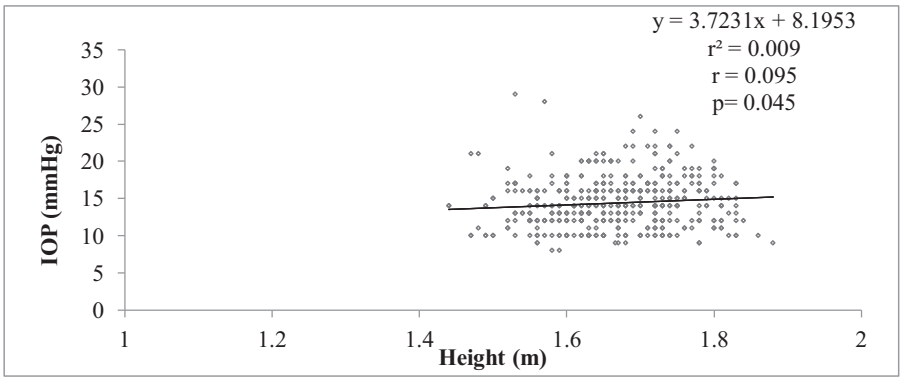

Figure 2: Scatter plot of the relationship between height and IOP. IOP, intraocular pressure.

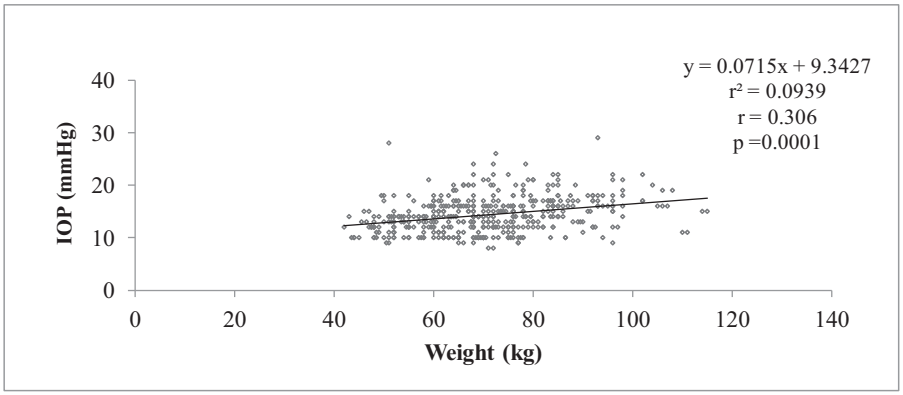

Figure 3: Relationship between weight and IOP. IOP, intraocular pressure.

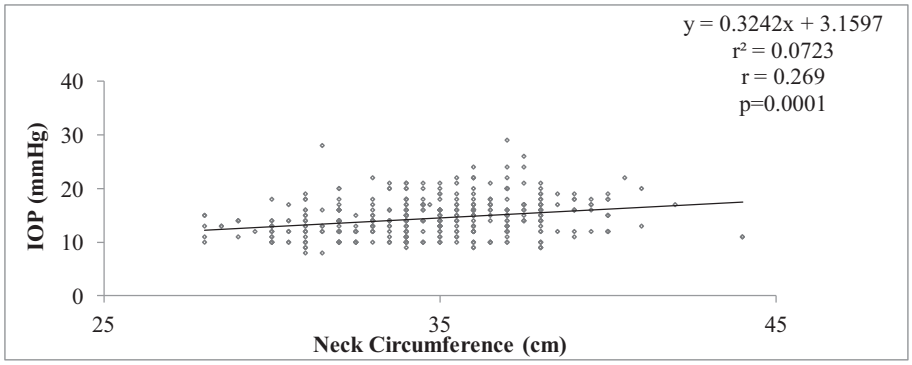

Figure 4: Relationship between neck circumference and IOP. IOP, intraocular pressure.

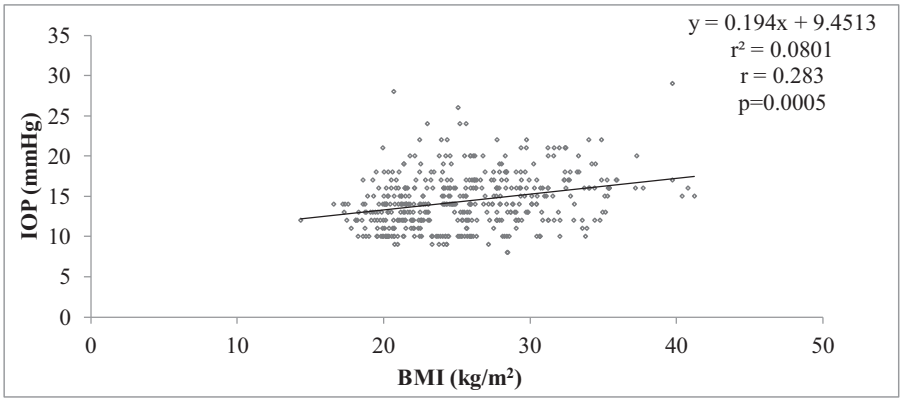

Figure 5: Relationship between BMI and IOP. BMI, body mass index; IOP, intraocular pressure.

Table 2: Distribution of IOP with different BMI in the subjects

Body Mass Index (kg/m^2)	No. of subjects	Intraocular pressure (mmHg)				
		Mean	SD	Minimum	Maximum	*P*-value
<18.5	13	12.54	1.27	10.00	14.00	<0.001
18.5–24.99	216	13.77	3.15	9.00	28.00	
25–29.99	137	14.70	3.46	8.00	26.00	
≥30	84	15.79	3.44	10.00	29.00	

BMI, body mass index; IOP, intraocular pressure.

difference in the anthropometric parameters was found when compared with studies in Europe and India.[9,10] This disparity may be due to the different study populations, locations, and socioeconomic status. The mean NC of the study subjects was found to be slightly higher than that reported by Kumar *et al.*[16] with a mean difference of +1.03 cm in males and +2.0 cm in females. The mean IOP using the applanation tonometry (14.4 ± 3.26 mmHg) was higher than the mean IOP among similar study populations reported by Mori *et al.*[13] in Japan with a mean difference of +3.1 mmHg. This disparity may also be due to the difference in study population (African vs. Japanese). Although when compared with a study by Lin *et al.*[4] a similar mean IOP values was observed.

These anthropometric parameters and IOP were also found to increase progressively with age ($P < 0.05$). This increase with age was significant for weight, BMI, and IOP but with a marginal increase in NC. The vertical growth of an individual is expected to cease at certain age thus the height was not correlated for age. This increase with age was similar to what was reported by Lin *et al.*[12] and Mori *et al.*[13] This finding further substantiated the effect of increasing age on structural changes in the trabecular meshwork which may result in a reduction in trabecular and uveoscleral outflow facilities and hence elevated IOP in older age group.[17] Aging is associated with moderate elevation of IOP and is also linked to progressive decline in cerebral and ocular perfusion.[18]

Following the regression analysis, a statistically significant relationship was found between weight and IOP ($P = 0.001$), BMI and IOP ($P = 0.0005$), and NC and IOP ($P = 0.0001$), whereas a borderline relationship was found between height and IOP ($P = 0.045$). The borderline relationship between height and IOP found in this study was in contrast to what was reported by Lai *et al.*[6] in the adult Tanzanian population

which showed a significant inverse relationship. They suggested that subjects whose height was below the mean in their gender group were approximately twice as likely to have an elevated IOP as those whose height was at or above the mean. However, many other authors[3,19] who did similar studies did not correlate height with IOP probably because it is a factor that cannot be modified amongst other reasons. The positive relationship found between weight and IOP was also similar to those reported by Mori *et al*.[13] and Zafar *et al*.[20] Weight unlike height is a modifiable factor that may change progressively depending on the individual's lifestyle modification.

The BMI is the most commonly used index for obesity and has been associated with glaucoma in some studies. It is a function of a person's weight and height. In this study, it was discovered that subjects with higher BMI had higher IOP in both sexes. IOP increase was significant at BMI levels $>25\,kg/m^2$ with a further increase at BMI level $>30\,kg/m^2$. Several studies[11-13] have shown the relationship between obesity and glaucoma using the BMI and IOP to determine the pattern and direction of the relationship. Reports from these studies on the direction of relationships have been controversial. Some declared obesity as an independent risk factor for glaucoma with a positive relationship with IOP,[11-13] a few studies reported no appreciable relationship between the two variables.[2,3] Some authors suggested that the reduction in aqueous humor outflow due to the elevation of intraorbital pressure with excessive intraorbital fat tissue and increase in outflow resistance for the episcleral vein through the increase of blood viscosity with weight gain may have led to the increased IOP.[3] Obesity also increase blood viscosity through increased red cell count, hemoglobin, and hematocrit, further increasing outflow resistance of episcleral vein and resulting in elevated IOP, making it an independent risk factor for glaucoma.[20] Moreover, obese persons have other cardiac risk factors such as hypertension, elevated serum cholesterol, and blood glucose levels which increase blood viscosity, reduces aqueous outflow, and elevate IOP.[21] Corticosteroid which has been found to increase IOP is also increased in obese persons and this may also explain the relationship between obesity and IOP.[21]

The NC is hypothesized by some authors to be a predictor of obesity and overweight, and that larger NC may be associated with a higher prevalence of cardiovascular risk factors such as hypertension and diabetes.[7] Majority of the studies carried out on NC were associating a larger NC to cardiovascular diseases and obesity with a dearth of information or published data on its relationship with IOP or glaucoma. The positive relationship between IOP and NC found in this study was in contrast with findings in the study by Theelen and colleagues[8] who found no significant relationship between NC and IOP. This may be due to the fewer numbers of subjects they studied. Possible reason for the association found in this study may be the distribution of upper body fat in the neck; where this may have a pressure effect on the blood vessels in the head and neck region. The pressure in the artery is much greater than that in the vein, whereas the flow through the vein is supported by gravity. Increased arterial pressure forces flow of blood upward despite large upper body mass, whereas gravity may not be sufficient to drain the blood through the vein into the heart, thus results in backflow and restriction along the superior vena cava. Further restriction and accumulation will cause increased episcleral backflow and elevated IOP.[22,23] It is imperative to say that people with short stout necks are at higher risk of developing glaucoma through elevated IOP than individuals with long slim NC.

Conclusion

The BMI and NC which are major indices of obesity were associated with IOP in this study. These parameters could be explored as potential modifiable risk factors in glaucoma screening and management. One of the limitations of this study is that inferences from this study are not representative of most communities because the study was limited to subjects in an academic environment which are more health conscious and less likely to be obese compared to the uneducated population. It is recommended that further research should be performed to further establish the relationship between anthropometric parameters and IOP in other environments and should incorporate subjects of all socioeconomic statuses and different occupations for better representation of the community.

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Conflicts of interest

There are no conflicts of interest.

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